

Facts, beliefs, and ambiguities about computed tomography and patient risk

Shawn Kruger

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ABSTRACT

Computed tomography (CT) has transformed diagnostic decision-making since its inception in the 1970s. The increasing radiation exposure received by patients is one of the key concerns linked with the growing use of CT. The association between ionising radiation and the development of neoplasia has been mostly based on extrapolating data from studies of survivors of the 1945 atomic bombs placed on Japan, as well as estimations of the higher relative risk of neoplasia among people working in the nuclear sector. However, the link between low-

dose radiation exposure from diagnostic imaging tests and oncogenesis remains unknown. Significant gains in radiation dose reduction have already been made because of better technologies. Several dosage optimization measures are easily accessible, including eliminating unneeded pictures at the ends of collected series, reducing the number of phases captured, and using automatic exposure management rather than fixed tube current procedures. Furthermore, in recent years, new picture reconstruction algorithms that lower radiation dosage have been developed with promising results. These methods make use of iterative reconstruction algorithms to provide diagnostic-quality pictures with less image noise while using fewer radiation doses.

Key Words: *Threshold-model; X-ray; Atomic bombs; Computed*

INTRODUCTION

Computed Tomography is a computerised x-ray imaging method in which a narrow beam of x-rays is focused at a patient and swiftly rotated around the body, creating signals that are processed by the machine's computer to create cross-sectional pictures or "slices" of the body. These slices are known as tomographic pictures, because they include more comprehensive information than conventional images. After the machine's computer collects a number of successive slices, they may be digitally "stacked" together to create a three-dimensional picture of the patient, allowing for better identification and localization of fundamental structures as well as any tumours or anomalies [1].

Working of CT: A CT scanner, unlike a traditional x-ray, employs a motorised x-ray source that spins around the circular aperture of a donut-shaped frame known as a gantry. A CT scan involves the patient lying on a bed that travels slowly across the gantry as an x-ray tube spins around them, sending narrow beams of x-rays into the body [2]. CT scanners employ digital x-ray detectors instead of film, which are placed immediately opposite the x-ray source. The detectors take up the x-rays as they leave the patient and send them to a computer [3].

A nurse examines successive brain CT images on an x-ray

reader in this image. The CT computer utilises complex mathematical algorithms to create a 2D picture slice of the patient every time the x-ray source completes one full revolution. The thickness of the tissue depicted in each picture slice varies each CT equipment, although it generally falls between 1 and 10 millimetres. When a full slice is completed, the image is stored and the motorized bed is moved forward incrementally into the gantry. The x-ray scanning process is then repeated to produce another image slice. This process continues until the desired number of slices is collected. The skeleton, organs, and tissues, as well as any anomalies the physician is seeking to discover, may either be shown individually or layered together by the computer to produce a 3D picture of the patient [4]. This approach offers a number of benefits, including the ability to rotate the 3D picture in space or examine slices in order, making it simpler to pinpoint the specific location of a problem.

Adverse effect of CT can be that the radiation from CT scans can harm bodily cells, including DNA molecules, resulting in radiation-induced cancer. CT scans expose patients to varying levels of radiation. CT scans can have a 100 to 1,000 times greater dosage than traditional X-rays when compared to the lowest dose x-ray methods. A lumbar spine x-ray, on the other

Editorial Office, *Journal of Clinical Psychiatry and Neuroscience*, United Kingdom

Correspondence: Kruger S, Editorial Office, *Journal of Clinical Psychiatry and Neuroscience*, United Kingdom; E-mail: clinicalpsychiatry@neurologyjournals.org

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hand, has a dosage comparable to that of a head CT [5]. The relative dosage of CT is sometimes exaggerated in the media by contrasting the lowest-dose x-ray techniques (chest x-ray) with the highest-dose CT procedures. The radiation dosage associated with a typical abdomen CT is comparable to three years of average background radiation in most cases. High cumulative doses of more than 100 mSv to individuals receiving repeated CT scans during a short time range of 1 to 5 years have been highlighted in recent research on 2.5 million and 3.2 million patients.

CT offers numerous benefits over other imaging modalities in that it can be completed in minutes and is widely available, allowing clinicians to more confidently confirm or rule out a diagnosis. It has had a significant influence on the field of surgery, reducing the necessity for emergency surgery from 13% to 5% and nearly eliminating numerous exploratory surgical operations [6]. The broad use of CT in clinical practise has been found to reduce the number of patients who need to be admitted to the hospital. CT's continuous technical advancements have contributed to make it a more appealing imaging modality, with improved spatial resolution and shorter scanning periods, resulting in a substantially expanded variety of therapeutic uses. Because some experimental and epidemiologic data has connected low-dose radiation exposure to the development of solid organ malignancies and leukaemia, the fast expansion in CT use has sparked great public concern about the levels of ionising radiation supplied during scanning. Large doses of ionising radiation are commonly regarded as increasing the risk of developing cancer over one's lifetime, but the link between low-dose radiation (of the order used in regular diagnostic exams) and oncogenesis is questionable. The association between radiation and the development of neoplasia has mostly been predicated on extrapolating data from studies of survivors of the 1945 atomic bombings in Japan [7]. According to a 2009 research conducted in the United States, CT is currently responsible for 75.4 percent of the effective radiation dosage supplied from all imaging procedures, whereas X-ray exams account for just 11 percent. This increased reliance on CT scanning has resulted in a nearly six-fold increase in cumulative per-capita effective radiation dose received from medical imaging in the United States between 1980 and 2006 (from 0.5 mSv to 3.0 mSv), and medical imaging is now the largest source of radiation exposure to humans other than natural background radiation (it contributed to more than 24 percent of the United States population's radiation dose in 2009). Since the mid-1990s, there has been an annual growth of over 10% in the use of CT scanning [8].

While there is little doubt that large doses of ionising radiation, such as those seen in nuclear disasters, increase a person's risk of cancer exponentially (analysis of the Chernobyl disaster's fallout has also revealed an increased risk of thyroid cancer in children exposed in utero downwind of Chernobyl), there is widespread disagreement about the level of cumulative radiation dose delivered by medical imaging that increases a person's risk of cancer exponentially. While many writers think that the Linear No-Threshold (LNT) model applies to the relationship between radiation and oncogenesis, others suggest

that there is a practical threshold below which cancer risks are no higher than an individual's background spontaneous risk. A recent study even claimed that low-dose radiation might boost the immune system and so protect people against cancer, a notion known as hormesis [9]. The claim that radiation causes cancer is a wide generalisation. Some organ systems are highly radiosensitive, whereas others have stronger defences against the effects of ionising radiation. Organs like the oesophagus, breast, and bladder, for example, are particularly vulnerable, although the rectum, pancreas, and prostate are far less so.

In recent years, the validity of the linear no-threshold model has been called into question even further. An examination of data from the Radiation Effects Research Foundation (REFR) (which tracked victims of the Hiroshima and Nagasaki explosions) compared cancer rates in these cities to cancer rates in other Japanese cities that were not damaged by the nuclear blasts. The researchers focused on the incidence of colon cancer (which is often used as a cancer indicator in the Japanese population) and discovered that individuals who got doses of radiation less than roughly 100 mSv had no elevated risk. It has been argued that attributing cancer risks to radiation doses of less than 100 mSv is muddled by other cancer risk variables in a given population. The REFR data matched a threshold-quadratic model of radiation-induced cancer better than an LNT model [10]. Another concern with extending atomic bomb survivors' experiences to those exposed to ionising radiation in the medical context is the underlying baseline variations in cancer risk between Japanese people and people from other ethnic groups. The linear-no-threshold model was first used to estimate radiation risk not because it has a strong biological and scientific base, but because it is simple and conservative (i.e., the model is more likely to over-predict rather than under-predict the neoplastic risk associated with imaging). There has been dispute about this concept since 1946, when Muller accepted his Nobel Prize for his work researching genetic changes in *Drosophila* caused by X-ray radiation (proposing the LNT model as a foundation for forecasting oncogenesis). Its legitimacy is being questioned by international communities. The Health Physics Society found that "risks of health impacts are either too tiny to be seen or non-existent" for doses below 50-100 mSv. The American Association of Physicists in Medicine agreed, stating that "predictions of hypothetical cancer incidence and deaths in patient populations exposed to such low doses are highly speculative and should be discouraged" at doses less than 50 mSv for single procedures and less than 100 mSv for multiple procedures [11].

While it was previously believed that even modest doses of radiation were linked with an elevated risk of oncogenesis, it now appears that a threshold-model of risk is more applicable, with the risk growing exponentially if cumulative doses of 100 mSv or more are attained. This, however, does not minimise the dangers of radiation or allow for complacency when determining the validity of an indication for a certain scan. Patients with long-term chronic medical issues, for example, are more likely to be exposed to radiation doses more than 100 mSv due to the demand for frequent imaging. Over a 15-year

period, it was discovered that 16 percent of Crohn's patients (this patient subgroup has an increased risk of small bowel lymphoma at baseline) had radiation exposure of >75 mSv, and a similar study assessing maintenance haemodialysis patients found that 13 percent of this population experienced a cumulative dose of > 75 mSv over a median follow-up of 3.4 years. While we know that ionising radiation poses some hazards to a patient, the news media can sensationalise and exaggerate the possible bad effects of radiation on carcinogenicity, which can cause worry in patients, particularly parents of children undergoing examination [12]. In most cases, the advantages of conducting CT much exceed the hazards. Medical physicians are increasingly confronted with challenging circumstances when patients decline CT screening in clinical contexts where CT scanning is obviously essential. Despite media coverage, patient awareness of the specific hazards connected with CT scanning might be lacking at times. The popular media has a propensity to focus on the ostensible (and often sensationalised) concerns of CT scanning's radiation exposure while disregarding the significant advantages in terms of speed and accuracy of diagnosis. Excessive focus or a lack of balance in the reporting of extremely rare incidences of error leading to extremely high radiation exposures from CT scanning, as was discovered when it was discovered that one centre had been exposing patients to radiation doses eight times higher than normal during CT perfusion scanning.

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